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New Bulletin of The Entomological Society of Victoria Inc.

THE ENTOMOLOGICAL SOCIETY OF VICTORIA (Inc)

MEMBERSHIP

Any person with an interest in entomology shall be eligible for Ordinary membership. Members of the Society include professional, amateur and student entomologists, all of whom receive the Society's News Bulletin, the Victorian Entomologist.

OBJECTIVES

The aims of the Society are:

(a) to stimulate the scientific study and discussion of all aspects of entomology,
(b) to gather, disseminate and record knowledge of all identifiable Australian insect species,
(c) to compile a comprehensive list of all Victorian insect species,
(d) to bring together in a congenial but scientific atmosphere all persons interested in entomology.

MEETINGS

The Society's meetings are held at the 'Discovery Centre', Lower Ground Floor, Museum Victoria, Carlton Gardens, Melway reference Map 43 K5 at 8 p.m. on the third Tuesday of even months, with the exception of the December meeting which is held on an alternative date. Lectures by guest speakers or members are a feature of many meetings at which there is ample opportunity for informal discussion between members with similar interests. Forums are also conducted by members on their own particular interest so that others may participate in discussions.

SUBSCRIPTIONS

Ordinary Member	$30
Overseas Member with printed bulletin	$65
Country Member	$26 (Over 100 km from GPO Melbourne)
Student Member	$18
Membership Electronic (only)	$20
Associate Member	$ 7 (No News Bulletin)
Institution	$35 (overseas Institutions $80)

Associate Members, resident at the same address as, and being immediate relatives of an ordinary Member, do not automatically receive the Society's publications but in all other respects rank as ordinary Members.

LIFE MEMBERS: P. Carwardine, D. Dobrosak, R. Field, D. Holmes, T. New, K. Walker.

Cover design by Alan Hyman.

Cover photo: *Megacmonotus magnus* taken at the Bush Blitz at Ned's Corner in November 2011 by Ken Harris. For more information see *Victorian Entomologist* V 44(1) p.7.

Minutes of the Entomological Society of Victoria General Meeting, Tuesday 17th June 2014 at Melbourne Museum

Attendance Members: Peter Marriott, Ken Harris, Laura Levens, Steve Williams, Glenise Moors, Marilyn Hewish, Wendy Moore, Geoffrey Weeks, Laurie Cookson, Ray Besserdin, Graham Patterson, Carol Page, Linda Rogan, Maik Fiedel, Peter Lillywhite, Peter Carwardine, Patrick Honan, David Mules
Visitors: Rob Moors
Apologies: Steve Curle, Ian Endersby, Daniel Dobrosak, Ken Walker, Geoff Hogg

The general meeting was opened by President Patrick Honan at 19:50.
Previous minutes - The General Meeting held on 15th April 2014 [reported in June 2014 Vic.Ent. 44 (3):48-50] M: Ken Harris S: Geoffrey Weeks

Correspondence: None reported.

Treasurer's Report:
As of 30th May 2014 General account balance: $6,395; Le Souëf account balance: $5,177; Publishing account balance: $15,566
Financial members: 95; Unfinancial members: 20
No new members' applications for this meeting.

No general business.

Members' presentations:

Linda Rogan - Dawson's Burrowing Bees *Amegilla dawsoni*.

Linda shared her experience of photographing Dawson's Burrowing Bees at Babbage Island near Carnarvon WA in August 2013. She and her husband had been seeking these bees at several known locations since early August. This Carnarvon location had been checked with no results in late July and August 5th and they were planning to leave the area on August 7th so made a last check at 14:00 on the 6th of August. To their amazement, as they drove slowly along the track, they began to see rather large insects flying low, apparently randomly on the track ahead. Stopping the car they quickly hopped out and confirmed that at least the male bees had

Fig. 1 *Amegilla dawsoni* Large male greets emerging female while small male hangs about hopefully. Photo L Rogan

Fig. 2 Several large males form a fighting ball around a lone female. Photo L Rogan

Fig. 3 One large male prevails and mates with female. Photo L Rogan

emerged. The next three days were spent observing the progress of bee activity regularly.

The experience was recorded with some video and close up photos that showed the newly emerged males patrolling the holes from which they had emerged and the females were yet to come. There was a lot of back biting as males jockeyed for position at holes where they sensed the females' activity. Increased excitement was visible just as a white furred female poked her head out (Fig.1). When she actually emerged, several males pounced on her at once, forming a fighting ball, usually with the female at the centre (Fig. 2). Both large and small males were photographed with the small one usually hanging back from the fighting. Sometimes males were killed and occasionally a female was accidentally beheaded. The video showed how eventually one male prevailed and escorted the female out of the area to mate (Fig. 3). Linda observed that occasionally the female broke away from the males while they were distracted by fighting. As the female bee was unmated and they are known to mate only once, an opportunity was presented for a small male. One such small male was shown mating and afterwards the female clasped a stem with her jaw and appeared to give herself a thorough cleaning.

Also photographed was a wingless female *Ephutomorpha* sp. Mutillid wasp that was entering the burrows and may have been laying its eggs as it was a known predator of other Hymenoptera species.

Linda noted that the females are able to determine whether eggs within their cells develop into females, small males or large males. John Alcock's work shows that males emerge earlier in the season and also earlier each day than females. The small males also emerge earlier than the large and this is reflected in the position that the female places the cells within her burrow, ie. the female cells are the deepest, the large males come next, and the small males are the shallowest cells within the burrow.

Linda passed around a female and 2 males that had been found dead around the burrows, to give a better idea of the actual size of these bees. All adults die within a few weeks time.

This August, Linda is planning to search for a similar *Amegilla* sp. along the Bulloo River in Queensland in an area where they were photographed and the images placed on a blog in 2009.

Marilyn Hewish and Peter Marriott Moths of Victoria part 5 (MOV5) (Fig. 4).

Fig. 4 Cover of MOV5.

Marilyn pointed out that this is her first book in this series. It covers 167 species in the family Geometridae, subfamily Ennominae. She stated it was a lot of work and its layout is similar to the first four excellent books. She is pleased to have it completed. She thanked all who assisted her, especially the co-authors Peter Marriott, Ted Edwards, Axel Kallies and Steve Williams as well as the photographers who kindly contributed additional images. Marilyn passed around a sample paper booklet demonstrating some of the material in the CD that accompanies the book; the 43 CD pages give additional information and photos on 19 species in MoV5.

Peter Marriott pointed out that 829 species in total have been covered now with the completion of MOV5, of which almost 80% include photos of living moths as well as pinned species. Few moth books published previously in Australia have illustrated larvae. Thanks to the work of Steve Williams, 17% of the Victorian species in the MOV series show the immature stages.
Future books will include two Noctuidae books, and the remaining Geometridae book (Ennominae part 2). Also likely will be a book on Cossidae with possibly Sesiidae and Sun Moths. As we develop each book we find previously unrecorded species and our readers contribute others. Though it is time consuming it is satisfying each time a book comes out. The known number of Victorian species is growing all the time.

Joshua Grubb - Adult Caddisfly Distribution in the Riparian Zone

Joshua's presentation was about his recently finished honours project titled above. He stated that most previous work has been done on caddisfly larvae rather than adults and their ecology/biology. His study was carried out at the Cumberland River in the Otways, near Lorne. In this location, the riparian zone was in a narrow valley with steep cliffs and therefore limited to ~50m. He used light traps with black plastic cylinders, which meant that the insect had to fly over it to be attracted to the light.

In his study, he determined the distribution of caddisflies across the riparian zone to determine if distance from the river correlated with sex, wing morphology or reproductive status. Six species were included in the study: *Cheumatopsyche modica, Tasimia*


Fig. 5a *E. russellius* photo Joshua Grubb.

Fig. 5b *E. russellius* another view photo Joshua Grubb

palpata, Agapetus kimminsi, Triplectides ciuskus, Ecnomina bula, Ecnomus russellius (Fig. 5a,b).

For all species, the females tended to be bunched up around the stream but the male *T. palpata* were found to increase in abundance further away from the river. In three species, males were relatively evenly distributed throughout the riparian zone and the remaining two were similar to females in being mostly near the river. Most females were sexually mature when collected and were more widely spread throughout the area than immature or spent females.

Wing aspect ratio and female maturity did not appear to significantly affect movement into the riparian zone, although over larger areas (topography limited the capture area to 50m from the river) they may play a larger role. These results suggested that the riparian zone is an important habitat for adults, particularly males. Overall, other behaviours, such as feeding or mate searching, may best account for occupying the riparian zone. These results are relevant for population estimates, since the males and female caddisflies were differentially distributed over short distances, and also for riparian restoration work, since it appears to be an important habitat for at least some species.
Given this, it is likely that changes to the riparian zone could affect nutrient transfers and diversity.

So the riparian zone is important for adults, particularly males. Even though the females are mainly found near the river, they may fly into the riparian zone. It appears that wing aspect ratio and maturity do not significantly affect movement into the riparian zone effect in this study, where geography limited the capture area into the riparian zone to 50m from the river. Other behaviours, such as feeding or mate searching, may best account for the attraction to the riparian zone.

Steve Williams New Findings in Box-Ironbark moths

Steve has been looking at moths of central Victoria around Bendigo for 5-6 years. He has been revegetating his 20 acre property and runs a light trap nearly every night. The latter is beginning to give him a long term idea of moth species and seasonal flight patterns.

Steve noted that although bats have been touted as great harvesters of mosquitoes, recent genomic studies of bats' stomach contents in NSW has revealed that moths, as a group, are the major component of bat diets. Steve has recorded activity profiles for between 500-600 species of moths and found that there is some moth species peaking at all times of year, even midwinter. This makes them a more reliable food source for the bats.

Steve has also been looking at differences between old growth forest remnants and regrowth forest in relationship to moth populations. The leaf litter and leaf mould area is remarkably different with

Fig. 6 Depths of leaf litter/mould measured at several old growth and regrowth sites.

areas around old growth trees having between 100mm and 140mm depth while regrowth areas up to 70 years old had mostly 5-10mm (Fig. 6) or a maximum of 40mm depth. This litter is where most of the moth pupae are found and it was felt that 40mm would be inadequate to protect moth pupae from extreme heat or from controlled burns. Thus for example, *Thalaina angulosa* which spends most of the year in its pupal form would be protected from burns in old growth forest but would be vulnerable in regrowth forest. He also noted that many moth species spend multiple years in the pupal form before emerging. The one moth that Steve found was less vulnerable to controlled burns is *Opodiphthera eucalypti,* the Emperor Gum moth. It does not make use of the litter layer, feeding high


Fig. 7 *Plesiolaea maritima* eggs top R, clockwise to fresh pupa bottom R.

Fig. 8 *Stangeia xerodes* larvae .

Fig.9 *Stangeia xerodes* adult.

in the tops of gum trees and it may also pupate there.

Steve also showed us slides of life cycles of several moth species that had not previously been recorded including *Plesiolaea maritima* that had pupated just that morning (Fig.7). The powerpoint presentation concluded with photos of the larvae and adult of *Stangeia xerodes*(Fig.8, 9).

Fig. 10 *Trichiocercus sparshalli* proceeding normally up the tree. Photo Wendy Moore

Fig. 11 Larvae motionless against the smooth tree bark.

Wendy Moore – Possible cooling strategy for caterpillars of Sparshall's Moth during a heatwave, Gasteruptiid wasp ovipositing, White-tailed Spider hunting

First Wendy showed an article from the Australian Geographic that documented how koalas hug trees in hot weather to keep cool. She then showed a series of photos of colourful processionary caterpillars of *Trichiocercus sparshalli*. She had observed them proceeding normally up a Brush Box tree in Coburg at 11:30 am one summer's day (Fig.10). A few days later at about the same time, in a spell of very hot weather, she found many of the caterpillars huddled together motionless on smooth fresh barked lower parts of the tree. Where possible they were under peeling bark or near knots, she presumed to be better hidden (Fig 11). They remained like that all day. Not until between 8 and 9 pm did the huddles break up and the caterpillars started proceeding back up the tree to the foliage. She wondered whether or not the caterpillars may also have been using the tree as a cooler in a similar strategy to the koalas. In subsequent days there were many dead caterpillars below the tree.

Secondly Wendy showed some photos she took of a White tailed Spider slowly stalking a house spider about its web. Although she watched for 1 hr and 20 min she never saw them make contact (Fig 12.)

Thirdly Wendy shared some slides showing a Gasteruptiid wasp with its extremely long ovipositor unsheathed and inserted into the hollow of a bamboo plant stake where she assumed some other

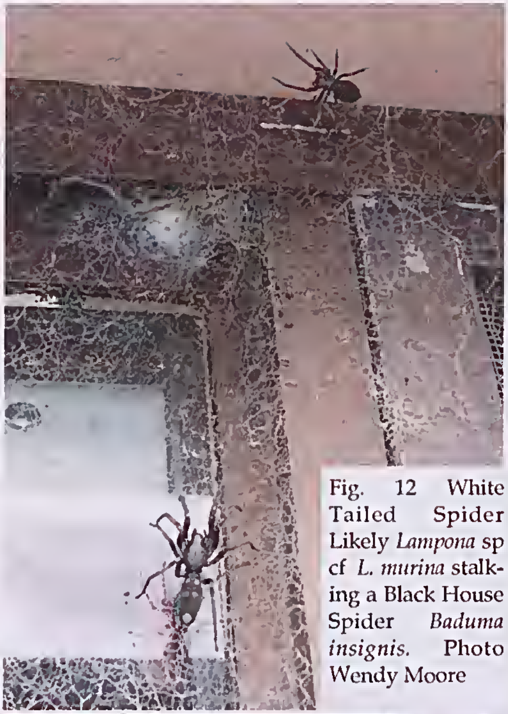

Fig. 12 White Tailed Spider Likely *Lampona* sp cf *L. murina* stalking a Black House Spider *Baduma insignis.* Photo Wendy Moore

Fig. 13 Gasteruptiid wasp using robust hind legs to position and re-sheath her ovipositor. Photos Wendy Moore

Hymenoptera had already placed its brood cell (Fig. 13).

Attendees were given the opportunity to purchase copies of MOV5 and Ross Field's butterfly field guide as well as a couple of other books being sold by members.

Meeting was closed at 21:30 leaving some time for members to chat before departing.

Synlestes weyersii :- Observations of mating and oviposition

by Ros Coy.

Synlestes weyersii damselflies commonly known as Bronze Needles, can often be seen hanging from vegetation along the creeks and rivers in the Deer Vale area of NSW. However, *Synlestes weyersii* damselflies have rarely been recorded mating or ovipositing.

Fig. 1 *S. weyersii* damselflies mating.

Fig. 2 A female *S. weyersii* working on 2nd hole in culm of *Scirpus polystachyus* at Deer Vale, NSW.

There is a tiny tributary to the Deer Park River along the edge of a flat area, which had a very low flow in 2014, due to unusually dry conditions. This tributary is well vegetated with tea-tree totally enclosing the creek in parts. At about 3pm on January the 6th 2014 as I was walking along this creek, I noticed a pair of Bronze Needles in tandem hanging from a sedge (*Scirpus polystachyus*). To my amazement they formed the wheel position before my eyes. They broke this wheel position after about 4 seconds (I thought I may have disturbed them). After another 12 seconds they resumed the wheel position and mated for nearly 6 minutes (Fig. 1).

This time, after breaking the tandem position, they hung together in parallel for another half a minute before they both simultaneously flew up off the stem. The male re-alighted in the same position whilst the female moved onto an adjacent stem where she curved her abdomen towards the stem as if to lay eggs.

They both then flew to the next stem along, where there were already 9 egg holes from a previous egg laying session. The female began the process of making new egg holes in a vertical line continuing on but slightly offset from the line of the previous egg holes (Fig.2).. The male hanging from the stem guarded her while she laid (Fig.3).

The female started by piercing the stem with the tip of her long curved ovipositor using a boring action, twisting the end of her abdomen in an arc of up to 90 degrees clockwise and anti-clockwise. She eventually pierced the stem to the full depth of her ovipositor. Before moving on to the next hole, she quickly covered the hole with the white fibrous matter that had accumulated from the sawing process.

Fig. 3 The male *S. weyersii* guarding the female during egg laying.

Fig. 4 *S. weyersii* pair and the egg holes just finished by the female in the *Scirpus polystachyus* culm to the right of the damselflies.

Each hole took more than 6 minutes to complete so that in about 2 hours, 20 holes were made (Fig.4).

The male guarded her the whole time chasing off a couple of Bronze Needles (or perhaps a single one twice) as well as a male Common Flatwing damselfly that came too close.

On January 20th 2014, I picked a stem near to the one with 29 egg holes in it. This one had 6 holes which were not so evenly distributed. The stem was very tough to cut even with a single edge razor blade. Breaking open the stem revealed chambers with up to 8 elongate translucent pale brown eggs inside which were pointing toward the entrance holes (Fig. 5). These eggs were just over 1mm long.

Fig. 5 *S. weyersii* eggs laid in *Scirpus polystachyus* pointing towards the entrance hole.

Fig. 6 Older *S. weyersii* eggs which have developed obvious internal structures as laid in a *Juncus* sp. rush stem. Photographed April 17th 2014.

On March 23rd I returned to the sedge where I had seen the Bronze Needle ovipositing to find the sedge had been grazed. Luckily the part of the culm containing the egg holes was still intact. The holes were now open, the eggs had hatched and the prolarvae would have hopefully made their way into the water.

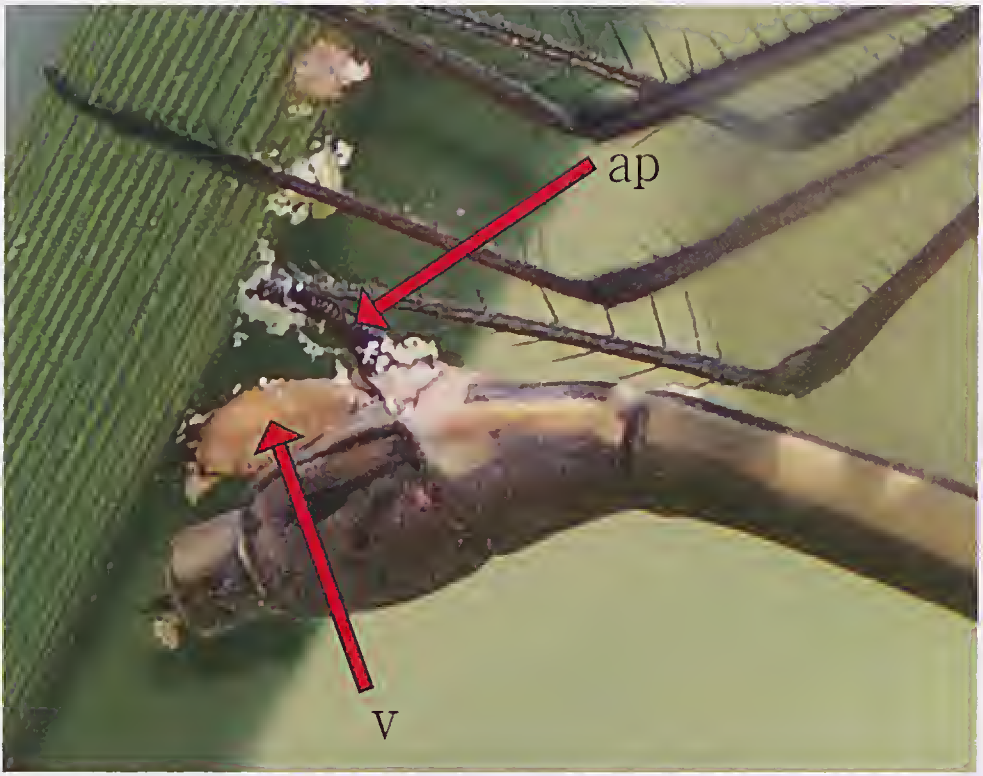

Fig. 7 *S. weyersii* process side view of ovipositor showing anterior processes (ap) and valve (v).

I decided to walk in the creek to check the vegetation for any more of the tell tale vertical rows of white fibrous clumps. I found very few sedge culms containing egg holes but quite a number of rushes did. These mostly looked recently made as the fibrous clumps were very white not brownish as on older egg holes. A sample of these rushes revealed prolarvae in the egg chambers which had burst from their eggs. The prolarvae were about 1.5mm long and darker brown than the eggs. You could see some internal structures inside (Fig. 6). When the prolarvae bursts out of the outer membrane the membrane is almost invisible.

Later on the same day on a different creek I saw another bronze needle ovipositing into a rush. Once again there was a male in attendance.

On April 11th 2014 at about 2.30pm on a different creek, I saw another pair of Bronze Needles in tandem. This pair also mated for about 6 minutes. This time the female started laying eggs within the stem where they broke the tandem position. This damselfly frequently changed position to oviposit on different stems and only laid for about 30 minutes. The male stayed close by, mainly hanging in parallel with a second female. However when another male Bronze Needle appeared, there ensued a head to head confrontation until the 2nd male retreated.

On page 226 of R J Tillyard's *The Biology of Dragonflies* published in 1917, he describes in amazing detail the method of oviposition in the genus *Synlestes* using *S weyersii* as an example. Tillyard writes that the dragonfly, after finding a suitable place on a reed, "makes a small incision with the sharp points of the anterior processes. The ends of the median processes slip automatically into this small

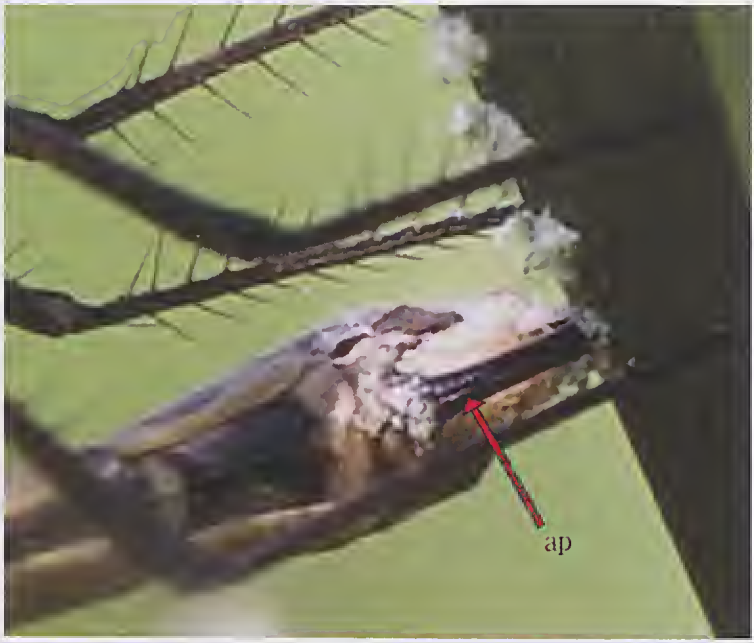

Fig. 8 *S. weyersii* processes. Ventral view of ovipositor showing anterior processes (ap).

slit, which is quickly enlarged by sawing with their teeth."(Figs. 7 & 8). This of course is very difficult to see but I did view a live female under a microscope, and saw that the damselfly could move the median processes independently of the anterior ones so that they slid up and down in the grooves of the anterior processes in a sawing motion. The saw like teeth on these processes bore out the chambers in which the eggs are laid.

Tillyard next describes how the eggs are laid and that when the hole is large enough "three or four eggs are placed in each hole". Here in Deer Vale I found the number of eggs varied from 3 to 9 eggs per hole but commonly 6 or 8 were laid.

Tillyard also mentions that "further holes are made in a gradually descending series not at all regularly placed" After examining quite a number of stems with egg holes along them, I found some holes were quite irregularly placed but there were also many containing evenly placed holes.

The link to see a video of *S weyersii* ovipositing is at

https://www.youtube.com/watch?v=qkBu3b8Emcs&feature=youtube

Reference

Tillyard, RJ 1917: 226 *The Biology of Dragonflies* Cambridge University Press: London

Additional Distribution Records for Victorian Dragonflies (Insecta: Odonata)

Final Instalment IAN ENDERSBY

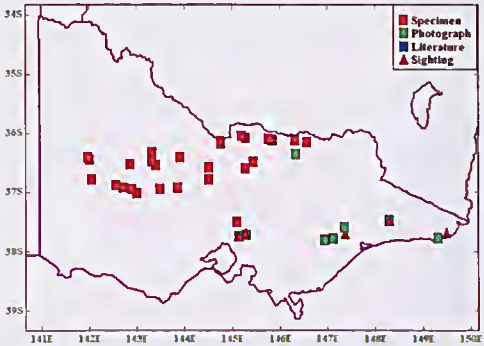

Fig. 94 Distribution of *Rhadinosticta simplex*

Rhadinosticta simplex (Figs. 94-99)

This species was thought to be rare in Victoria with only one known museum specimen, taken at the Plenty River taken in 1954. It is found mainly along the eastern seaboard from southern NSW to beyond the Qld border. There is another aggregation of specimens from northern Qld. NSW SRS surveys in 2005 yielded many larval specimens north of the Great Divide in Victoria. As long as the lamellae are intact the larvae are easily identified as they are the only Victorian species which has a strong constriction in the caudal gills. Photographs have complemented the northern distribution with numerous observations in rivers south of the Great Divide. While fairly nondescript it is unlikely to be confused with any other Victorian damselfly. Males often show pruinescence at the end of the abdomen and this can be seen in (Figs. 95 and 98). All damselflies

Fig. 95 *R. simplex* Raymond Creek
Photo: R. Richter

Fig. 96 *R. simplex* Raymond Creek
Photo: R. Richter

(Zygoptera) oviposit endophytically into vegetation, often into floating aquatic plants. (Fig. 96) shows a female ovipositing into a branch of a shrub which, presumably, overhangs the water. Upon hatching the larvae will drop into their new aquatic habitat. To the best of my knowledge the oviposition behaviour of this species has not been recorded before.

Fig. 97 *R. simplex* Wonga Park
Photo: R. Richter

Fig. 98 *R. simplex* Warrandyte
Photo: R. Richter

Fig. 99 *R. simplex*
Kangaroo Ground
Photo: F. Pierce

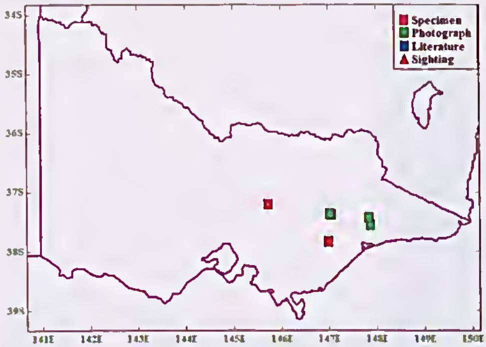

Fig. 100 distribution of *Spinaeschna tripunctata*

Spinaeschna tripunctata (Figs. 100-105)

This species has a curiously disjunct distribution with a cluster in northern NSW and another in southeastern NSW extending into Victoria. Only two specimens are known from the state, from Alexandra and Valencia Creek. *Spinaeschna* is defined by having five longitudinal ridges on the dorsum of segment 10 of the male and a pair of pale oval spots on the top of the frons, neither character being easily observable in the field. Easier to see is the pattern on segments 3-7 of the abdomen. Each segment has two pale subtriangular spots close together near the centre and two more widely separated, almond shaped spots at the base. This occurs in both sexes and is obvious in Figs. 101, 104 and 105. Larvae inhabit fast, rocky streams and Fig. 102 shows a female ovipositing into such a habitat.

Fig. 101 *S. tripunctata*
Tambo River
Photo: R. Richter

Fig. 102 *S. tripunctata*
Wonnangatta
Photo: R. Richter

Fig. 103 *S. tripunctata*
Wonnangatta
Photo: R. Richter

Fig. 104 *S. tripunctata*
Wonnangatta
Photo: R. Richter

Fig. 105 *S. tripunctata*
Wonnangatta
Photo: R. Richter

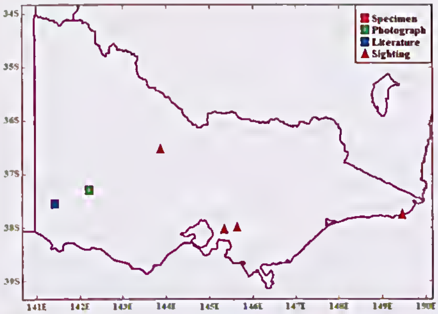

Fig. 106 Distribution of *Tramea loewii*

Tramea loewii (Figs. 106-107)

John Hutchinson (1977) first reported this species from Victoria. It was observed during an excursion by the Entomological Society of Victoria to the "whipstick" near Inglewood in 1973. Its distribution is widespread except for southern Australia where it seems to have a vagrant status. Close examination of Fig. 107 will show the distinctive red markings at the base of the hindwing which gives this genus the colloquial name of Saddlebags in America.


Fig. 107 *T. loewii* Grampians Photo: R. Richter

Conclusion

This completes a review of distribution range extensions for the rarer or less well known dragonflies from Victoria. New information was based primarily on high quality photos which allowed unequivocal identification. These extensions are more likely to be due to increased observations rather than a physical expansion by the species. Other challenges where new information would be valuable are: *Apocordulia macrops* - a crepuscular species, almost all adult specimens were raised from larvae collected from the Kiewa River at Killara; *Caliagrion billinghursti* - five specimens were collected in 1905 and four in 1906, both series from Alexandra, and not reported since from Victoria; *Austroepigomphus praeruptus* - one larva collected by the EPA from the Richardson River, central NW Victoria (the type locality is Adelaide); *Austrogomphus angelorum* - known from only five adult specimens from the Murray River at Corowa, Renmark and west of Wentworth. Thanks to those who provided photographs and editorial comment.

References: This article has been continued in regular instalments from Victorian Entomologist 43(5) October 2013 and the full reference list occurs on p.99 of VE 43(5).

Overview of the Butterfly Database: Part 8 – Counts of Sites, as a Glimpse into Past Exploration

Kelvyn L Dunn

Summary

Part 2 in this series on the database project examined the 'numbers of records' and the 'mean numbers of records per species' across various areas of Australia. It exposed a greater paucity from the western and northern sections of the continent and highlighted the variation in figures across the states and territories (after these political jurisdictions were weighted according to the land area each involved). It also reviewed likely factors that promoted these imbalances. Part 4 compared a moderate subsample (n = 23,450 records, that comprised my own field observations and specimen vouchers) with the independent remainder of the database (n = 121,844 records). Similar imbalances to those detected in the whole dataset (Part 2) were present in each of the subsamples across the broader regions and to a variable extent, across political jurisdictions. The temporal spread of the 'mean numbers of records per species' when examined by calendar month was, for the larger part, also in similar proportion in the two subsamples. This eighth part takes this a stage further and investigates the number of unique 'one-minute sites' across the same regional divisions. Applying the same approach and using the same dataset (which contained 145,294 records at the time of analysis), it compares the skews detected in the 'number of sites' with those evident in the 'number of records' and 'mean number of records per species'. These counts of sites provide for minimal measures of the extent of exploration that has occurred across the one and a half centuries of survey effort, nationwide.

Introduction

The amateur collecting process, which underpins the history of butterfly study in Australia, is an opportunistic and selective approach (Sands 1999) that has floated most of the knowledge now available on the distribution of the 434 species. There has been, without doubt, a tremendous effort (compared with other insect groups) and much dedication of recreational time by those so committed (Moulds 1999); but traditional collection aesthetics, which are at odds with randomised data accumulations and an objectively structured approach to fact gathering, have had an impact (Dunn 2009). To help counter this uneven blend of art and science, New and Sands (2004) called afresh for wider exploration for threatened species, which in turn reflects upon the few locations available for many other species too, both in museum series and literature sources currently available. The limited exploratory effort overall (which this infers and is in fact the reality) has resulted from several factors, which are briefly refreshed. Firstly, there has been a tendency to rework classic sites (New & Sands 2004), those of seasoned workers handed down the generations. This practice has often been at the expense of those habitats nearby which have not been investigated (Sands & New 2002), but with that spatial loss has come much seasonal information instead (Dunn 2009). Secondly, workers have often surveyed close to their places of residency (because of financial and recreational time constraints), and for this reason, the butterfly faunas of regions close to the major cities are now very well known; in process, it has led to an over-accumulation of information from the southeast of the continent (Dunn 2010). Aestheticism has limited off-seasonal work (when adults are worn), and the occasional replacement of specimens deemed less than perfect also amounts to a loss of scientific information (Dunn 2010); that standard has been ranked secondary. Eventually, with expertise (and the confidence that usually comes with that) many amateurs go on to explore more remote areas (using that handed down knowledge skilfully reapplied). In time, the drive for sought-after species (often those that are cryptic in their habitats and hard to detect, or of patchy distribution and which are met with less often) takes the stalwart increasingly farther afield (Dunn 2009); that in turn provides opportunities for impromptu exploration en route, as a secondary gain. It is then that insect collections, initially assembled as Art (as displays of order and beauty), begin to bring forth the Science of distribution and discovery.

22. Accumulation of sites – measures of exploration

The database stands a large repository of knowledge of butterfly species' spatial and temporal distribution (Dunn & Dunn 2006). Supportive of this, Dunn and Franklin (2010) found, in a study that

explored the adequacy of representation of butterfly species' distributions in northern Australia, that the database does have a spatial measuring potential; its coverage of many regions is acceptable. Because the fauna of the Arnhem region of northern Australia (the area of focus in that report) is only moderately studied compared with most regions in eastern Australia (but not poorly so, as is the situation for the desert areas in the west), it provided a suitable test case for the database in terms of its wider applications. Hence, the database now seems suitably representative in coverage to enable estimations of the extent of exploration across regions. A comparison of counts of the number of sites across particular regions (sometimes weighted to balance for land areas or other factors) can achieve this. The rationale here is, that since each unique site visited (across all workers) equates to a single exploratory event, then a count of all sites for each region correlates as a minimal estimate of the actual exploration that has taken place across those regions. This comparison has fewer assumptions linked to it than do those for counts of records or calculations of catch. However, a count of sites cannot balance for the actual spatiality of those sites within each region (that is, how far apart they are from each other). Nonetheless, a simple examination of the number of sites, whether this is across time-periods or broad regions, offers a glimpse into past and present exploration.

22(i). Definition of sites

In order to assess sites, a definition needs to be established. There are two main kinds of 'site' referred to in the database project reports; namely 'descriptive sites' (as locations) and 'one-minute sites' (as map plots). A 'descriptive site', as an assertion of provenance on specimen labels, is the one familiar to most. It is correct in stating, that oftentimes an assortment of similar 'descriptive sites' (as provided by various workers or, sometimes, the same worker across time) may actually refer to the same 'one-minute' site. That said, only 74% of the 'locations' stored in the database project's gazetteer have coded for uniquely different 'one-minute' sites; hence there are 10,795 unique 'one-minute' sites available at this time of report (see Table 9). This means that 26% of those 14,393 'descriptive locations' (as retained for those records they concern) have been judged by the database makers (KLD & LED) as variant descriptions of another, already documented, one-minute site. This artefact of written description has created ambiguity at times as to the intended location (all facts considered) when labels are geocoded by proxy, many years or even decades after the capture event (Dunn 2013). The 14,393 geocoded locations represents 97% of all descriptive locations available – the remaining 3% has been left unassigned; the locations intended were too vague, unclear, or the labels are now indecipherable due to the ravages of time. (At this point it is useful to note that the comparisons in the numbers of sites given in Part 2 (Dunn 2009) specifically refer to 'descriptive locations' and that the total of 'one-minute' sites actually involved would be proportionally less).

23. Annual exploration in Australia – a temporal analysis

The number of sites provides for an overview across the history of butterfly survey in Australia, and when presented by year, an informative picture emerges; in effect, tens of thousands of labelled specimens, now sorted, reveal that exploratory activity of collectors – a view largely hidden until the digital era of sorting capability. Figure 9 shows the survey trends across 126 years of collecting history since the middle of the 19^{th} century. It indicates that there has been an exponential growth in the number sites (and hence exploration) until 1990 when the number of sites maximised at 790 for that year. A precipitous decline then extended through to 1998 (inclusively); it involved two separate clear falls with a short interlude of minor flux localised to the middle 1990s. The period from 1992 to 1998 (representing the overall decline in exploration) aligns with a paradigm shift in attitudes towards insect collecting that took place over several years. It was during this time that some states listed species as protected fauna and prosecutions for collecting began (Sands 2005); and it was reported that during that time too, that knowledge of new locations began to be withheld from "the wider community or conservation authorities" (Sands 2005: 7). This upheaval marks the close of the 'Common & Waterhouse Era' and the start of the 'Conservation Era' (see Dunn 2011 for discussion and justification of these era's start and end-points). In effect, the level of exploration now appears to have returned to that of the 1960s (which was in a separate period called the 'Tripartite Era'). Because data is still incoming for the late 2000s and (now) the early 2010s, it is likely too early

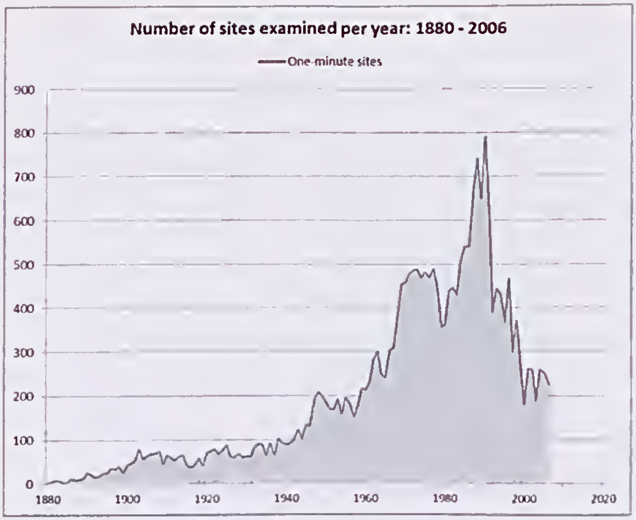

Figure 9. A measure of collectors' exploratory effort: the number of sites per annum from Australia over the last 126 years. (Compiled May 2010, database holdings n=145,294 records)

to include these years and conclude from these at this time. When more data comes to hand, the emerging trends will be clearer and will provide more insight as to what the future predicts in terms of the continuity of productive amateur survey for butterflies (and other insects).

24. A nationwide comparison of regional exploration

The number of encounter records that accumulate from a particular region is often in direct proportion to the diversity of that regional fauna and needs weighting to be more meaningful. The 'catch' (the mean number of records per species) moderates the record counts according to the faunal richness of the region and offers appropriate balance. It provides a broad measure of the sampling intensity across regions (Dunn 2009, 2010) as a weighted derivative of the counts of records; it is more informative in the comparison of skews too. In areas of sparser sampling, catch may align proportionately to the number of sites examined, particularly where observers provided a 'census' inventory – meaning, a list of all species (not just some) encountered at a site for the duration of the visit. This is not the norm for historic butterfly collections, though; such were, and still are, biased samples (Sands 1999) and represent only a partial take of the broader fauna present at those sites visited (Dunn 2013), often with focus on those kinds that are rare or of particular interest (to the workers concerned). Importantly too, if wing condition of a targeted species proved unsuitable for display purposes, a collector may take no material as evidence of that visit. At other times a collector may take just a single quality specimen, which may get damaged (by pests or handling) over time and so discarded; then that solitary evidence of an exploratory event is also lost with it – hence the evidence is of minimal exploration.

24(i). Skews evident by counts of records – a simple spatial analysis

The distortions in species richness nationwide and the variable seasonal influence on adult presence across regions where they regularly breed are each important, and each ties in to species' biogeography. These distortions intrinsically link to the sources of the butterfly data, namely, the collector process (as overviewed earlier), rather than the sampling approaches of the database makers (Dunn 2009). To examine the holdings for skews in the 'numbers of sites', I divided Australia into several large regions; these comprise the 'eastern'/'western' and 'northern'/'southern' sectors, as defined previously (Dunn 2009, 2010). These regional sectors, broadly balanced by land area, had suitably compared the numbers of records that have been sampled across one and a half centuries of survey effort, nationwide. Again, in terms of the numbers of records, the database clearly reflects an oversampling of the south and east, relative to the north and west (Dunn 2009, 2010). The sampling unevenness exposed previously is very likely due to artefacts of the opportunistic and unstructured approach of most collectors (Dunn 2009) and because of extremes in faunal richness nationwide (Kitching & Dunn 1999). The sharpest gradients in faunal richness occur towards the northern and eastern coastal regions of the continent (which are wetter environments), and where counts often exceed 80 species. The inland and west (which is predominantly arid and semi-arid) have a much lower (but a more uniform) diversity, and these regions are where, for the most part, that there are about 20 species recorded.

In the three analyses that follow, unless stated otherwise, all references to the term 'site' intend the 'one-minute site' – a place of survey that has been geocoded to one-minute resolution, and which is discrete from all other one-minute sites.

24(ii). A comparison of the number of one-minute sites across regions

(a). East-west disparity: Eastern Australia (as defined by longitudes greater than and equal to 135° 00'E) contains 92% of the national fauna compared with only 41% recorded in the west (Table 9). These two faunas are very unevenly balanced; the east shows a dramatic richness narrowly along the Great Dividing Range and eastern shore board, which exacerbates that difference (Kitching & Dunn 1999). Within the broader regions, the Wet Tropics (in the northeast of Queensland) has over 200 species compared with only 40 or fewer species in the southwest of Western Australia. This difference in richness makes for an interesting comparison of the two broad regions in terms of the catch (a weighted count of records indicative of survey intensity) and the number of one-minute sites represented (the exploratory component). Indeed, there is a 2.25-fold increase in species richness in the eastern portion; 401 species recorded for the east is 66% above the species richness of the west (Table 9). Not surprisingly, given the richness divide (in a 9: 4 ratio), 82% of sites in the whole database have come from the east (Table 9) – this reflects nearly a five-fold skew (4.7 times) for the East-West (E-W) division. It is slightly higher than the skew in the catch, which is similarly dramatic with its 4.1-fold increase towards eastern Australia (Table 9). In addition, the ratio of the 'numbers of sites per species' is two-fold in favour of the eastern region, as is also the ratio of the 'numbers of records per site' (Table 9); both imply a greater survey frequency and sampling effort (respectively) in eastern Australia. The skew to the east (for sites) reflects the greater exploration of that region and the rich fauna has likely enticed continued exploration across the timeframe. The eastern residency of most historic and contemporary contributors to the database (Dunn 2008, 2010) has been important as an underlying influence; ongoing focus has occurred in those regions that are closer to where contributors live or once lived, at the expense of the west.

(b). North-south disparity: Southern Australia (as defined by latitudes greater than and equal to 25° 00'S) contains 63% of the national fauna, compared with 81% recorded in the north (Table 9). These two faunas are more balanced compared with the E-W divide. About 78% of sites that have accumulated nationwide have come from the south. Indeed, the whole database has a prominent 3.5-fold sway (in sites) towards southern Australia (Table 9). Southern Australia has a large fauna of 275 species (Table 9), which is nearly 79% of the species richness of the north. Hence, the lure of the moderately richer fauna of the north has been less influential across this division (than compared with that found for the E-W). Coupled with this, the remoteness of northern Australia from the south (from which it is extensively isolated by desert and arid areas) has resulted in much less attention to it. The difference in the catch is less dramatic. It is still much offset, given that it has a 2.4-fold increase towards southern Australia (Table 9). This offset is supportive evidence of increased survey effort, similarly at odds with the moderately richer fauna in the north (in ratio of 5: 4). In addition, the 'number of sites per species' is 4.5-fold in favour of the south, again suggestive of greater survey frequency. This has resulted in more locations discovered per species. In contrast with the other findings, the ratio of the 'number of records per site' is about 2: 1 in favour of the north (Table 9) (not the south). This may be linked to the higher species richness of the north, which will contribute more records per site and which would require more work in areas of lesser richness to offset. There have been few workers resident long term in northern Australia over the last 150 years (Dunn 2010). Hence, the southern residency of many historic and contemporary contributors to the database has been important as an underlying influence in the overall sway to the south; ongoing focus has occurred in those regions that are in closer proximity (compared with the north) to where they live or once lived.

Table 9. Regional data composition: Sites & Records (compiled May 2010) (whole database n=145,294 records).

Regions	Total species (%)[ratio]	No. of records (%) [ratio]	No. of one-minute sites (%)	One-minute sites - ratio	Mean one-minute sites/ species [ratio]	Mean records/ sites [ratio]	Catch: Mean records/ species [ratio]	Catch ratio:
Eastern Australia Longitude E>=135°00′	401 (92%) [2.25:1]	130,836 (90%) [9.2:1]	8891 (82%)	4.7	22.2 [2:1]	14.7 [2:1]	326.3 [4.1:1]	4.1
Western Australia Longitude E<=134°59′	178 (41%)	14,264 (10%)	1905 (18%)	1.0	10.7	7.5	80.1	1.0
Northern Australia Latitude S<=24°59′	350 (81%) [1.27:1]	50,307 (35%)	2375 (22%)	1.0	6.8	21.2 [1.9:1]	143.7	1.0
Southern Australia latitude S>=25°00′	275 (63%)	94,793 (65%) [1.9:1]	8421 (78%)	3.5	30.6 [4.5:1]	11.3	344.7 [2.4:1]	2.4
Political Australia	**434**	**145,294**	**10,795**	—	**24.8**	**13.5**	**334.8**	—

NB: The subdivisions of the 'numbers of records' sum to 145,100 (not 145,294 as given for Political Australia). These counts include all acceptable records that have been assigned a geocode, including remote offshore islands (e.g. Christmas Is.) that are part of political Australia, but do not include those contributions where the intended locations are vague, ambiguous, or remain undetermined due to legibility issues (n=194 records; 0.13% of the holdings). Those locations in dispute are without a geocode and will not be detected and sorted by the algorithms that seek these code requirements; because of this the figures obtained will underscore (very slightly) the actual number of 'one-minute sites' represented by the total records held in the database.

To be continued.

Corrigendum

Part 4 – see Dunn (2010, p.98) [*Vic. Ent.* 40(5): 98-109]; the following caption needs correction:

Figure 1. The author's survey sites up to and including April 2010 (n=1,915 sites, each differing by one-minute resolution).

The map figure actually comprised 2,958 sites, each differing by one-minute resolution (not '1,915' as stated in the caption).

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DIARY OF COMING EVENTS

Next meeting Tuesday 19th August
Museum Victoria
The Lord Howe Island Stick Insect
Speaker: Rohan Cleave
Note 7:45 pm start

Month	*Date*	*Planned event*	
October	21st	General meeting	Members' presentations at Museum Victoria
December	TBC	Members' excursion	**Note:** Date and venue to be confirmed and to be earlier than the third Tuesday to avoid busy holiday

2014 Council meetings
16th September, 18th November

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